directionality can be a desired attribute in some applications, such as a source for ion implantation or ion milling, or a plasma torch application.

VII. Spatial Plasma Density

Fig. 5A is a simplified cross-section of a toroidal core 501 inside a shroud or cover 503 with a dielectric gap 505. An upper edge 507 of the cover forms a reference plane. A portion of the chamber wall is shown as dotted line 508. Fig. 5B is a simplified cross-section of a representative ion density distribution 511 along the radial distance from the center axis 509 of the torus in the reference plane. Alternatively, a constant ion density could be shown versus distance from the reference plane. Such a curve would have a similar shape. The ion density has a maximum 513 along the center axis of the torus, that is, ions are essentially ejected outside of the torus along the center axis. It is believed this ion distribution arises due to crowding of the plasma within the inner circumference of the toroidal cover. The ion density is bilaterally symmetrical about the plane of intersection with the circumference of the torus, and has theta symmetry about the center axis. The ion density also generally represents the temperature of the plasma, so the temperature at the center axis is hotter than elsewhere at a similar distance from the reference plane.

The absolute ion density depends on many factors, such as the dimensions of the transformer structure, including the inner diameter of the cover and radius of the core, the pressure, the plasma species, and the AC drive frequency. However, it is possible to drive the transformer at a sufficiently high frequency to establish an essentially steady-state ion distribution as shown. Thus, the transformer-coupled plasma generator can maintain an enhanced ion density or temperature above the reference plane formed by the upper edge of the cover. If a more uniform plasma is desired, the inner diameter of the transformer structure can be increased relative to the diameter of the core. Additional plasma shaping can be done with shaped cores or core covers, or by using electro-magnetic fields.

VIII. Ion Implantation Source

Fig. 6A is a simplified diagram of an ion implantation system 600 according to another embodiment of the present invention. The system includes a transformer-coupled ion source 602, which is driven by an AC power supply 20. A gas delivery system 603 provides the precursor gas or vapor to the ion source 602. ~~The~~

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